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Does Technological Linkage in Contract Farming Increase Farm Productivity and Efficiency? The Case of Hybrid Paddy Seed Cultivation in Undivided Andhra Pradesh§

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Abstract

Increasing interest for knowing whether technological and input linkages in contract farming increase the farm productivity and efficiency, this paper provides an empirical evidence by undertaking a case study of hybrid paddy seed cultivation through contract farming in undivided Andhra Pradesh. Heckman sample selection model has been used to estimate the productivity differences between contract and non-contract farmers and stochastic production frontier has been used to measure the technical efficiency. The results have indicated that contract farmers could achieve higher productivity and more efficiency by growing contract crop compared to non-contract crop. However, non-contract farmers could achieve higher productivity and more efficiency in growing non-contract crop compared to contract farmers. The results have pointed out many avenues for future research; these include the autonomy of farmer in contract farming, technology spill-over effect, and impact of modern technology in contract farming on farmer's traditional knowledge and local environment.

Key words: Contract farming, farm productivity, technical efficiency, agricultural technology

JEL Classification: Q1, Q12

Introduction

The adverse impact of globalization on farmers in developing countries, especially in India, needs to be seen against the fact that agricultural sector is not internationally competitive on account of low productivity, high cost of production, lack of institutional support and other related factors. For addressing these issues, appropriate institutional innovations/platforms are required in Indian agriculture to deliver new technology, knowledge, inputs and a better market. The private sector could play a role in providing a range of services from input and technology supply to crop assembly and marketing. The experience of the West as well many African and Asian countries discovered that contract farming[1], where the private sector plays a major role, would help in increasing crop productivity and output growth in agriculture sector by delivering better technology, coordinating producer's and consumer's market along with strong

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[1] Contract farming is an "alternative market institution that establishes an agreement (formal or informal) between grower(s) and firm(s) (exporters or processors) to produce a particular agricultural commodity under forward contract". It is a situation in which the relationship between the agribusiness firm and the farmers takes the form of an expert endowing apprentice with resources, knowledge and skills.

grass-root linkages (Little, 1994; Key and Rusten, 1999; Bauman, 2000; Eaton and Shepred, 2001; Narayanan and Gulati, 2002; Singh, 2002; Key and MacBride, 2003; Simmons *et al*., 2005) and bring higher efficiency among small farmers (Dev and Rao, 2005; Ramswami *et al*., 2005) due to the better organizational pattern.

The argument follows like –for growing the contract crop, contractor (agro-processing firms) facilitates the cultivation[2] to procure high quality and quantity in meeting the consumer's demand (Key and Rusten, 1999; Key and MacBride, 2003; Singh, 2002; Eaton and Shepred, 2001). This reduces the farmer's risks in accessing inputs, modern technology and market price fluctuations (Hueth and Ligon, 1999) and also increases the financial leverage. Since processors have direct interest to improve the product quality, they usually offer improved and better technical assistance more effectively than the government's agricultural extension services (Minto, 1986). They also have an incentive to learn from farmer's experience and modify their advice accordingly. The technical assistant of a contracting firm visits the farmer's field and manages the production from land preparation to crop harvesting – advices the farmer on applying seeds, pesticides, and fertilizers in time and in correct proportions. Contract farming could, therefore, serve to relieve farmer from credit and input-output market constraints, and enabling him to apply inputs at an optimum level. Better technology and management practices in contract farming brought by the processors increase the overall farm productivity and efficiency.

The studies have also shown that contract farmers are able to achieve higher productivity compared to the non-contract ones (Key and MacBride, 2003; Kumar, 2006; Dileep *et al*., 2002; Ramswami *et al*., 2005; Ching-Cheng *et al*., 2006) and is seen as a source in enhancement of farmers' economic status (Key and Rusten, 1999; Dev and Rao, 2005; Singh, 2002; 2005; Kumar and Chand, 2004; Kumar *et al*., 2007).

The method of production and extension services provided by a processing firm to a farmer for growing a particular crop, may even lead to a spill-over effect. The spill-over effects could occur in two cases – (a) the interaction with firm's technician by a farmer in nurturing the contract crop improves farmer's knowledge and has positive impact on non-contract crops; and (b) it could occur to non-contract farmers as well learning from neighbour's experience. In this regard, Warning and Key (2002) note that spill-over effects in contract farming have led to an increase in productivity of non-contract crops grown by the contract farmers. For example, the positive technology and investment spill-over effects from contract farming of organic coffee to food crop farming in Uganda (Bolwig, 2012). The farmers who followed organic and several of good farming practices that were promoted by the contracting firm — use of manures on vegetables, maize and banana, construction of water trenches on steep land, and better weed control — observed higher yields due to this intervention.

The effectiveness of contract farming in terms of farm productivity and efficiency in India has not received much attention among scholars. Some studies have examined the average efficiency across contract and non-contract farmers (Dileep *et al*., 2002; Kumar, 2006; Ramaswami *et al*., 2005) and no study seems to have measured the individual farm efficiency and the determinants therein. In addition, these studies are lacking not only in terms of their approach but also in terms of methods that are used. While Dileep *et al.* (2002) used marginal value of product (MVP) and marginal factor cost (MFC) to estimate resource-use efficiency. Kumar (2006) used simple Cob-Douglas production function to estimate production efficiency. It is argued that an ordinary least square estimation is likely to be bias when the random unobservable factors such as ability are not uniformly distributed within the population of contract and non-contract farmers. In such a situation, the error-term will coincide with unobservable variables and so output will be over-estimated. The only study by Ramaswami *et al*. (2005) has estimated the sample selectivity bias, while others have not. Hence, a careful scrutiny of whether contract farming increases the farm productivity and efficiency is in order. The contribution of this paper is in providing an empirical evidence on the impact of supervision and input linkages in contract farming on farm productivity and efficiency among hybrid paddy seed growers in undivided Andhra Pradesh. In this context, the present paper seeks to examine the following research

[2] Contractor provides all variable inputs such as parent seeds, fertilizer, pesticide and techniques for growing the contract crop (Singh, 2002; Eaton and Shepred, 2001; Sliva, 2005).

questions: (1) does contract farming improve crop productivity and efficiency of farmers? and (2) if yes, then what are then factors that induce farmers to achieve higher farm efficiency?

Contract Farming, Productivity and Efficiency

Very few empirical studies have discussed the impact of contract farming on farm productivity and efficiency (Kumar, 2006; Ramaswami *et al.*, 2005; Chang *et al.*, 2006; Key and MacBride, 2003; Bellemare, 2009). Some of them have found differences in crop productivity between contract and non-contract farmers, while others have not. The study by Kumar (2006) on tomato and potato farming under contract mode of production in Punjab, found no difference in farm productivity between contract and non-contract farmers; however, differences are observed when it comes to the determinants of crop output. For example, in case of contract farmers, inputs like agro-chemicals have higher elasticity on crop output, however, it is the labour in case of non-contract farmers. A study on contract farming of rice in Taiwan by Chang *et al.* (2006) have observed that farm-size contributes to total output of contract farmers, while other than farm-size inputs like fertilizer and labour contributes to output when it comes to non-contract farmers. The results suggest that profit of a contract farmer is highly correlated with the acreage devoted to a particular crop, but not in the case of non-contract farmer. By studying poultry farming in Andhra Pradesh, Ramswami *et al.* (2005) have observed that contract farmers are more productive than the non-contract farmers due to better use of inputs and better technical advice from the processing firms.

Whether supervision in contract farming improves the crop productivity, Bellemare (2009) found that the number of field visits by the firm's extension officer had a significant and positive impact on farm productivity in a study of vegetable farming in Medagascar. For the growers who had completed a few years of education, the number of visits by the extension officers was more effective and had a positive impact on farm productivity. Similarly, Key and McBride (2003) have observed that contract farmers are substantially more productive (around 20% higher over non-contract farmers) after correcting selectivity bias in studying the hog farming in the USA. They have explained this productivity difference in terms of technology diffusion in contract farming – contract farmers used better technology compared to non-contract ones.

In terms of efficiency, Kumar (2006) has argued that farmer's efficiency level depends on the type of crop not the knowledge transfer by the processing farm –contract farmers are economically efficient than the non-contract ones in growing potatoes; however, no differences exist between these two in growing basmati rice. By estimating marginal value of product (MVP) and marginal factor cost (MFC), Dileep *et al.* (2002) have uncovered that tomato contract farmers use resources efficiently compared to non-contract ones. Similarly, outcome is observed from rice cultivation in Taiwan (Chang *et al.*, 2006). They have also uncovered a negative relationship between the age of a farmer and efficiency – older farmers tend to be inefficient when they produce independently. No significant variation in efficiency is observed by farm scale, by full-time versus part-time or by location.

An analysis of poultry farming in Thailand, Brazil and India by Delgado *et al.* (2003) has noted that contract farmers are efficient than non-contract ones and in addition, large farmers are more efficient as compared to their counterpart smaller ones in Thailand and Brazil.[3] However, the results become different when it comes to India — small farmers are more efficient compared to large ones. By estimating production efficiency, Ramaswami *et al.* (2005) have found, due to the lower feed-conservation ratio in contract poultry farming, the contract famers were more efficient than non-contract farmers.

Empirical Model

The production function was estimated to measure the crop productivity and technical efficiency of the sample farms (both contract and non-contract). A Cobb-Douglas production function in log-linear form was fitted to the observations using ordinary least squares. The estimation of production function involved two steps. In the first step, production functions for individual crops, viz. hybrid paddy seed and normal paddy, grown by contract and non-contract farmers, was estimated. In the second step, the sample contract

[3] Large farmers attained higher level of profit efficiency for both broilers and layers compared to small farmers.

and non-contract crops grown by the farmers was pooled and regressed output as well as interacted by a contract dummy (1 for contract crop, 0 otherwise) in an additive form for the intercept. Further, the non-contract crop (normal paddy) grown by both contract and non-contract farmers was pooled together and regressed output in an additive form for the intercept as well interacted by a contract dummy (1 for contract farmer, 0 otherwise). The specific Cob-Douglas that is fitted in step one is as follows:

Model 1: $\ln Q = \alpha + \beta_1 X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \varepsilon$ …(1)

where,

Q = Total output of a particular crop in a particular season (in quintals),

α = The intercept,

X_1 = Land allocated for the particular crop (acres),

X_2 = Total labour (number of human days) used for the particular crop,

X_3 = Total cost of power (including machine and animal) incurred for the production of particular crop (₹),

X_4 = Total expenditure on agro-chemicals and manure used for production of particular crop (₹), and

X_5 = Region dummy.

Model 2: $\ln Q = \ln \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \varepsilon$ …(2)

In Model 2, X_6 is the contract dummy (1 for contract farmer and 0 otherwise) and is taken as an independent variable.

Pooling the sample contract and non-contract farmers and regressing with output would give the impact of contract participation on productivity, but the result may not be robust due to the selectivity bias in the process of sampling. To deal with the issue of selectivity bias, a sample selection model proposed by Heckman (1979) has been used. Sometimes, unobservable variables may be correlated with both an operator's decision to participate in contract farming and a farm's productivity. Thus, the sample selection model provides an unbiased estimate of the impact of farmer's participation in contract farming on farm productivity.[4] The model assumes a joint normal distribution between the errors of selection equation (contract/no contract) and the treatment equation (production function).

Let the latent variable C_i^* equal the net benefits to a farmer from contracting instead of independent production, i.e.

$$C_i^* = Z_i^* y + u_i \quad \text{…(3)}$$

where, C_i=1 if C_i^*> 0, otherwise 0.

Z_i is a vector of operator, farm, and regional characteristics. If the latent variable [C_i^*] is positive, the dummy variable indicating the participation in contract farming C_i equals one, and otherwise zero. We are interested in measuring the impact of contract farming on farmer's performance due to the contract participation y_i, i.e.

$$y_i = X_i\beta + C_i\delta + \varepsilon_i \quad \text{…(4)}$$

where, C_i is a dummy variable indicating whether a farmer participates in contract farming or not. X_i is the vector of operator, farm and regional characteristics. The question is whether δ measures the extent of contract participation (assuming that the rest of the regression model is correctly specified). The answer is no, if the typical farmer who likes to join in contract farming would have higher productivity whether or not participating in it. If the above observation is correct, then the least squares estimates of will actually be an overestimate.[5]

We cannot simply estimate the performance of a farmer under contract production (Equation 4) because the decision to enter into a contract may be determined by unobservable factors (i.e. managerial ability, regional or the like). If this is the case, the error-terms in Equations (3) and (4) will be correlated, leading to biased estimates of δ. To derive unbiased parameter estimates, we can use a two-stage approach, starting with a probit estimation of Equation (3). In the second

[4] For more details, see Heckman (1979).

[5] The same observation applies to estimates of the treatment effects in other settings in which the individuals themselves decide whether or not they will receive treatment.

stage, we can compute the inverse Mills ratio,[6] which is included as an additional term in the OLS estimation of Equation (4). The two-stage Heckman procedure is consistent, *albeit* not efficient.

Technical Efficiency

Stochastic production frontier[7] was used to measure the technical efficiency. The stochastic production frontier function that fitted was as follows:

$$\ln y_i = \alpha_0 + \sum_{i=1}^{6} \beta_i \ln x_i + \beta_5 x_5 + v_i + u_i \qquad \ldots(5)$$

where, all variables are defined in Equation (5) and v_i the two-sided 'noise' component, and u_i is the non-negative technical inefficient component of the error-term. The noise component v_i is assumed to be symmetric, distributed independent of u_i. Thus, the error-term in the stochastic production frontier becomes $\varepsilon = v + u$.[8] Maximum likelihood method of estimation enables us to obtain the maximum possible output function. These require that density function for random variables v_i and u_i are given. It is assumed that follows a half-normal distribution due to the nature of definition and follows a conventional normal distribution (Kalirajan and Shand, 1994).

Data and Variable Construction

The data for study were collected from the Karimnagar district of undivided Andhra Pradesh state in southern India in the year 2009. The survey covered 155 farm households; however, the empirical estimation is based on 150 sample households after data filtration. Among them 81 farmers have an agreement with seed processors (Pioneer and Pro-Agro) to produce and supply the paddy seed at pre-agreed price[9], while 69 are non-contract farmers. The non-contract farmers don't grow the contract crop (i.e. hybrid paddy seed). Since hybrid paddy seed is grown by the contract farmers only, it is difficult to assess directly the impact of contract farming on farm productivity and efficiency. To address this problem, a comparison has been made between contract and non-contract farmers in growing a similar crop (normal paddy for consumption). There are two reasons behind for selecting normal paddy as non-contract crop — it constitutes a major share of gross cultivated area and the cultivation practice of hybrid paddy seed is mostly similar to normal paddy, except the method like flowering and cross fertilization between male and female plants.

A two-stage sampling method was followed in selecting farmers (both contract and non-contract). The first stage involved a purposive sampling for selection of villages where contract farming is being practised based on the prior information provided by processing firms. In the next stage, purposive sampling was also pursued to identify the contract and non-contract farmers. Information on farmers those engaged in contract production of paddy seed was collected from firm's record. Only a small number of farmers—around 15 to 20—were engaged in contract production in a village, and so to get an adequate number for the analysis, four villages were selected. Non-contract farmers were selected randomly without any further stratification from the peripheral areas with a similar cropping pattern as that of the contract farmers have. From each village, 15 to 20 non-contract farmers were surveyed to go with contract farmers.

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6 For details see Greene (2005): pp. 781-790 and Key and MacBride (2003).

7 The production frontier provides the upper boundary of production possibilities, and the input-output combination of each producer is located on or beneath the production frontier.

8 The productivity and technical efficiency have been estimated with the help of Stata 10.

9 The contract between paddy seed grower and processing firms are very simple. Farmers are provided with free foundation seeds and extension advice and must deliver paddy seed especially female seed to respective processors. The organizer (who is intermediate between farmer and processing firms) arranges a number of technical staff required for conducting periodic field inspections at various stages of seed production. It is the duty of organizer to ensure field inspections by seed certification staff. Farms are usually visited four times by the technical staff – during land preparation, 30 days after sowing, then between 40-60 days during pre-flowering stage and then a week prior to harvest – and are paid by the intermediary agency to undertake advisory and monitoring role. The organizer arranges for completion of all formalities to get seed certified from concerned processor. For the service of organizer, firm pays minimum commission. The amounts of commission fee decide at the annual meeting conducted between service providers and processing firm.

Results and Discussion

Table 1 reports the mean differences in inputs-use between the contract and non-contract crops and highlights several differences. The statistics revealed the differences in use of agro-chemicals and labour between hybrid paddy seed and paddy crop grown by a contract farmer. However, no significant difference was observed in the amount spent on animals and machine power between the two. A look at the inputs-use pattern in growing of paddy crop by contract and non-contract farmers, revealed a significant difference in all the inputs, except agro-chemicals. Coming to output, no significant difference was observed between them. On the whole, the input-use patterns indicated that contract farmers were spending a higher amount compared to non-contract farmers.

Production Function and Efficiency

Before discussing production function and efficiency, let us find the yield level among contract and non-contract crops. The data presented in Table 2 revealed a wide variation in average production per acre of contact and non-contract crops; however, no significant difference was observed between sample contract and non-contract farmers. The average yield of the paddy seed was 18.52 q/acre, while it was around 21 q/acre per acre for normal paddy being grown by contract farmers. The average yield of normal paddy grown by non-contact farmers was also 21 q/acre.

In terms of yields, it was observed that for paddy seed the yield ranged between 10 and 24 quintals per acre, while it was from 15-25 q/acre in the case of non-contract farmers and 10-28 q/acre among contract farmers. The yield variability around mean was higher for the crops grown by contract farmers than their non-contract counterparts. Among contract farmers, 41 per cent of farmers could achieve more than 20 quintals of normal paddy per acre, while 46 per cent of non-contract farmers could achieve same amount of normal paddy.

Productivity

We next analysed the average contribution of each input to output without pooling both crops/farmers (contract and non-contract) together and then pooling together to estimate the productivity difference between the two. Cobb-Douglas production function was estimated through ordinary least square (OLS) method

Table 1. Test of equality of means of inputs used per acre for contract and non-contract crops

Mean difference in input-use between paddy seed and paddy is grown by a contract farmer					
Variables	Hybrid paddy seed (Contract crop)	Paddy for consumption (Non-contract crop)	Mean difference	t-statistics > |*t*|	Prob.
Yield (q/acre)	18.52	20.81	-2.30	-6.49	0.00
Labour (human days/acre)	96.96	29.00	68.16	74.49	0.00
Chemicals and manure (₹ /acre)	4051	2867.25	12.43	1184.61	0.00
Power (animal and machine) (₹ /acre)	4346.45	4360.47	-14.01	-0.107	0.91
Mean difference in input use between contract and non-contract farmers in growing paddy					
Variables	Paddy grown by contract farming	Paddy grown by non-contract farming	Mean difference	t-statistics	Prob. > |*t*|
Yield (q/acre)	20.81	21.04	-0.23	-0.63	0.53
Labour (human days/acre)	28.79	26.26	3.99	2.53	0.01
Chemicals and manure (₹ /acre)	2867	2836	30.00	0.300	0.76
Power (animal and machine) (₹ /acre)	3048	2330	718	16.32	0.00

Table 2. Distribution of yield contract and non-contract crops

(q/acre)

Yields rates	Contract farmer		Non-contract farmer
(q/acre)	Paddy seed (Contract crop)	Paddy (Non-contract crop)	Paddy (Non-contract crop)
10-12	2 (2.47)	2 (2.47)	0
12-14	2 (2.47)	0	0
14-16	5 (6.17)	0	1 (1.45)
16-18	16 (19.75)	8 (9.8)	5 (7.25)
18-20	49 (60.49)	38 (46.91)	31 (44.9)
20-22	6 (7.41)	16 (19.75)	18 (26.1)
22-24	0	9 (11.11)	7 (10.14)
> 24	1 (1.23)	8 (9.88)	7 (10.14)
Mean	18.52	20.81	21.04
Minimum	10	10	15
Maximum	24.5	28	25
Variance	4.36	7.47	3.86

Note: Figures within the parentheses are percentages.

for the contract and non-contract crops. The standard error of the estimates, coefficient of multiple determinations (Adjusted-R^2) and coefficients of independent variables are presented in Table 3. The results can be interpreted as the measure of average performance of sample farmers evaluated at sample mean input levels because of the nature of OLS (Meeusen and Broeck, 1977). More than 95 per cent of variation in output could be explained by the selected direct inputs in the analysis of contract and non-contract crops.

The factors labour, agro-chemicals and region have shown a significant contribution to the total output of contract crop (hybrid paddy seed), while the inputs like labour, agro-chemicals, power and region have depicted a significant impact on output achieved for non-contract crop (normal paddy) grown by the contract farmers. However, it is different in the case of non-contract farmers where land, labour and power have shown a significant impact on output of non-contract crop. It seems that output of both contract and non-contract crops grown by the contract farmers is mostly affected by the use of agro-chemicals, but it is not the case of non-contract farmers. Further, land has not been found to have a significant influence on crop output of contract farmers, but it has an influence in the case of non-contract farmers. The results suggest that the output of non-contract crop grown by a non-contract farmers is highly correlated with the acreage devoted to non-contract crop. This outcome is in the line with the findings of Chang *et al*. (2006) and Kumar (2006).

The contribution of labour to output varies across crops. As expected, the estimated coefficient of labour is higher for contact crop than non-contract crop, which supports our hypothesis that contract crop is a labour-intensive crop requiring additional labour, especially for flowering and weeding. The coefficient for agro-chemicals has been found to be higher for contract crop than non-contract crop, which indicates that for growing of contract crops requires more fertilizer than of non-contract crops. Interestingly, it does not have any significant impact on the crop output in case of non-contract farmers. In this regard, Singh (2008) has argued that contract farmers use agro-chemicals at a high rate during the initial period, leading to a decline in the quality of soil, and further they try to use more and more agro-chemicals year after year to maintain yield level. Other than factors of production, region has significant impact on output of crops grown by the contract farmers while it is not seen in the case of non-contract farmers. One of the reasons for it is the better interaction of farmers with service provider in Jamikunta Mandal, which enabled them to achieve a higher output as compared to farmers in Kamalapur Mandal with no such service.

Table 3. OLS estimates of Cobb-Douglas production function for sample farmers

Variables	Contract farmers		Aggregate[b] (Contract & non-contract crop)	Non-contract farmers	Contract and non-contract farmers[c]
	Paddy seed (Contract crop)	Paddy (Non-contract crop)		Paddy (Non-contract crop)	Non-contract crop
Constant (α)	-2.98 (7.8)*	-2.60 (-3.70)*	1.06 (0.96)	-6.74 (-4.14)*	-1.80 (3.16)**
Land (β_1)	0.10 (0.46)	0.10 (1.21)	0.77 (4.38)*	0.10 (1.55)*	0.10 (3.19)**
Labour (β_2)	0.59 (4.92)*	0.32 (2.76)*	0.016 (0.11)	-0.26 (-3.06) *	0.21 (2.39)**
Chemicals (β_3)	0.27 (4.16)*	0.13 (2.17)**	0.11 (1.60)***	0.10 (0.26)	0.10 (1.42)
Power (β_4)	0.10 (1.45)	0.43 (5.67)*	0.08 (1.68)**	0.56 (4.97)*	0.45 (5.93)*
Region[a] (β_5)	0.15 (3.80)*	-0.10 (-2.00)**	0.01 (0.97)	0.26 (0.05)	-0.1 (-2.05)**
Dummy (β_6) Contract crop =1, Non-contract crop = 0			0.19 (1.60)***		
Dummy (β_7) Contract farmers=1, Non-contract farmers= 0					-0.26 (-5.09)*
Adjusted R^2	0.95	0.96	0.95	0.95	95
No. of observations	81	81	162	69	150
F	0.00	0.00	0.00	0.00	0.00

Notes: Figures within the parentheses show the t-value

*, ** and *** show the significant at 1 per cent, 5 per cent and 10 per cent levels, respectively.

(a) Villages in Jamikunta mandal = 1 and villages in Kamalapur mandal = 0.

(b) In this equation both contract and non-contract crops grown by the contract farmers were pooled together taken contract dummy as independent variable.

(c) In this equation both contract and non-contract farmers were pooled together and taken the contract dummy as independent variable.

The differential intercept among contract and non-contract crops and slope coefficients have been found statistically significant at 10 per cent level. The results indicate that the output per crop is, on an average, 19 per cent higher for contract crop than non-contract crop. It could be thus argued that contract farming has a positive impact on farm productivity. To examine the difference in productivity between contract and non-contract farmers in growing non-contract crops, both contract and non-contract farmers were pooled together and regressed with a contract dummy as an independent variable (1 for contract and 0 for non-contract farmers) in an additive form. The outcome indicated that the slope and coefficient of differential intercept are statistically significant (at a 1% level) and implies that a contract farmer achieved less output, on an average, by 26 per cent than a non-contract farmer. For robustness of the result, the sample selection bias was rectified with the help of Heckman sample selection model in estimation of a production function. The results of maximum likelihood estimation are presented in Table 4, which show that the differential intercepts between contract and non-contract farmers are statistically significant (at 5% level) with negative signs. This points towards a difference between the production functions of the two types of farmers, implying different technologies. Further, the negative coefficient indicates that a contract decreases the productivity of a contract farmer in growing non-contract crops by 33 per cent than a non-contract farmer. This result suggests that farmers lose their control over own managerial decisions on farming when they produce crop under the contract farming system.

Technical Efficiency

The technical efficiency was measured through half-normal method (Kumbhakar and Tsionas, 2006) and the empirical results of best production performance of a sample farmer are given in Table 5. The implicit assumption in the analysis is that there is

Table 4. Sample selection model maximum likelihood estimates: Production function of rice among contract and non-contract farmers

Variable	Constant (α)	Land (β_1)	Labour (β_2)	Power (β_3)	Agro-chemicals (β_4)	Type of farmers (β_5)
Coefficient	-1.49	0.13	0.10	0.49	-0.04	-0.33
Z-Value	-1.38	3.55*	0.47	2.89**	0.63	-2.79**
χ^2				0.00		
Rho				-0.01 (-0.02)		
log Pseudo likelihood				-35.32		
ln sigma				-1.88 (-18.98)*		
Number of observations				150		

Notes: Table presents the maximum likelihood parameter for the sample selection model. Dependent variable in the equation is the contract (1, 0); dependent variable in the production function equation is log of production. In the regression, all inputs have been normalised relative to the sample mean.
The standard errors are robust.
* and ** show the significant level at 1 per cent and 5 per cent levels, respectively.

Table 5. Half-normal of maximum likelihood estimation of frontier production function

Variable	Contract farmer		Non-contract farmer
	Hybrid paddy seed (Contract crop)	Paddy (Non-contract crop)	Paddy (Non-contract crop)
Constant (α)	-2.80 (-3.92)***	-2.88 (-4.52)***	-7.90 (-6.40)***
Land (β_1)	-0.10 (-0.71)	0.10 (1.93)**	0.10 (1.13)
Labour (β_2)	0.75 (7.88)***	0.29 (3.24)***	-0.94 (-4.49)***
Power (β_4)	0.10 (1.17)	0.45 (5.76)***	1.17 (7.31)***
Agro-chemicals (β_5)	0.21 (2.18)**	0.16 (2.16)**	0.10 (0.43)
Region[a] (β_6)	-0.10 (-2.47)***	-0.10 (-1.56)	0.01 (0.63)
Sigma square	0.03	0.04	0.030
log likelihood	84.29	55.46	50.35
σ_u	0.17	0.18	0.16
σ_v	3.04	0.067	0.07
λ (Lambda)	0.56	2.62	2.28
Chi-square	39.27 (0.00)	7.15 (0.00)	4.43 (0.02)
Number of observations	81	81	69

Notes: *, ** and *** show the significant level at 1 per cent, 5 per cent and 10 per cent, respectively.
Figures within the parentheses represent the standard error
(a) Villages in Jamikunta mandal = 1 and villages in Kamalapur mandal = 0.

Hick's neutral technical change.[10] This means that the intercept coefficients of Equation (5) are slightly higher than of Equation (1), while the slope coefficients is more or less the same for both the set of equations. It is worth to note here that in the case of non-contract crop (paddy) grown by a contract farmer, coefficient of land is statistically significant as not like in Equation (1). In the case of non-contract farmers, the coefficient of land shows statistical significance in Equation (1) as not like Equation (5).

Table 6 presents the farm-level technical efficiency of contract and non-contract crops, and also across

[10] A change is considered Hicks neutral if it does not affect the balance of labour and capital in the production function.

Table 6. Frequency distribution of farm-specific technical efficiency in stochastic production frontier

Technical efficiency (%)	Contract farmer		Non-contract farmers
	Hybrid paddy seed (Contract crop)	Paddy (Non-contract crop)	Paddy (Non-contract crop)
50-59	2 (2.5)	1 (1.2)	
59.01-69.0	2 (2.5)		1(1.4)
69.01-79.0	5 (6.2)	10 (12.3)	6 (8.7)
79.01-89.0	37 (45.7)	32 (39.5)	23 (33.3)
89.01-100	35 (43.2)	38 (46.9)	39 (56.5)
Total	81 (100)	81 (100)	69 (100)
Mean	89	87.47	89.58
Difference (t)	1.78***		2.11**

Notes: The difference was calculated between contract (rice-seeds) and non-contract (rice) crops grown by contract farmers. To compare contract and non-contract farmers, the difference was calculated between the non-contract crop (rice) grown by contract and non-contract farmers.

**, ***show significance at 5 per cent and 10 per cent levels, respectively

Figures within the parentheses show percentage of total.

contract and non-contract farmers, which indicates a wide variation in the efficiency level across crops. A mean efficiency of 89 per cent was observed for the contract crop and 87 per cent for the non-contract crop grown by the contract farmers. The results also indicated that technical efficiency enabled 43 per cent of contract farmers to achieve 89.01 -100 per cent of output in the case of contract crop, whereas it is 46.9 per cent for the non-contract crop. The testing here is based on the means of two series — contract and non-contract crops — to know whether they are statistically different from one another or not. The results of t-test show a significant difference in technical efficiency between contract and non-contract crops grown by a contract farmer.

The mean technical efficiency of growing non-contract crop by non-contract farmers is 89.58 per cent and 56.5 per cent of the farmers could achieve 89.1-100 per cent level of technical efficiency. The average technical efficiency between contract and non-contract farmers indicated that non-contract farmers could achieve a higher efficiency level (89.58%) than the contract farmers (87%) in growing of a non-contract crop. This result is contradictory to our hypothesis that contract farmers will be more technically efficient than the non-contract ones due to the positive spill-over effect in the farm.

However, this result could be the outcome of over-dependence on processing firm for new technology; leading to an erosion of their traditional knowledge (Glover, 1984) due to innovations introduced in contract production. Another explanation could be that though contract minimizes the risk, it also reduces a farmer's autonomy, giving him no opportunity to develop entrepreneurial abilities and management skills. That too results in the farmer losing touch with his own techniques of production (Chang *et al*., 2006). The other implication is that due to resource constraints, contract farmers could not allocate valuable family labour and inputs to the non-contract crop (normal paddy) grown by them. This is in line with our results that contract farmers share only 6 per cent of their family labour for normal paddy, whereas the figure for non-contract farmers is around 19 per cent.

The efficiency levels across farms of different sizes—small, medium and large—were estimated and are presented in Table 7. The results reveal that small farmers could attain a higher level of efficiency than medium and large farmers in growing a contract crop. However, the pattern is opposite when it comes to non-contract crop grown by a non-contract farmer. Explaining why small farmers attain a higher level of efficiency, Bardhan (1973) argues that small farmers use more current inputs per acre due to market imperfections in dual agrarian economy (Sen, 1962) and hence produce more output per acre. On the other hand, a large farmer is more dependent on the hired labour. For a small farmer, labour is a family resource

Table 7. Average technical efficiency across farm size

Farm size	Contract farmer		Non-contract farmer
	Hybrid paddy seed (Contract crop)	Paddy (Non-contract crop)	Paddy (Non-contract crop)
3 acres (Small)	92.00	88.00	86.57
3.01-6 acres (Medium)	87.00	88.50	90.50
6.01 acres (Large)	88.70	86.00	89.61
Total	88.47	87.00	89.00

Table 8. OLS estimates of factors influencing farm-specific production efficiency[11]

Variables	Contract farmers		Non-contract farmers
	Hybrid paddy seed (Contract crop)	Paddy (Non-contract crop)	Paddy (Non-contract crop)
Constant	0.84 (8.04)*	0.85 (19.20)*	0.89 (22.15)*
Age of farmer (number of years)	0.01 (1.01)	0.01 (0.93)	-0.001 (-1.15)
Education (number of years)	-0.01 (-0.60)	0.01 (1.76)***	0.01 (2.18)**
Times of pesticide use	0.10 (2.67)*		
Times of fertilizer use	0.05 (2.03)**		
Family size (14-65 years of age)		-0.01 (-1.44)	0.002 (0.67)
R^2	0.20	0.23	0.30
	Prob > F*	Prob > F*	Prob > F*

Notes: *, ** and *** show the significant at 1 per cent, 5 per cent and 10 per cent levels, respectively. Figures within the parentheses show t-values.

or is available at a rate lower than the market rate. Thus, the imputed price of labour to the small farmer is lower than that of the large ones and because of more labour-use per acre, the output per acre increases.

Determinants of Technical Efficiency

Based on the Schumpeterian theory of economic development, technical efficiency is assumed to depend on factors that determine an individual's technical knowledge and understanding, and the socio-economic environment in which he or she works (Kalirajan and Shand, 1994; Kalirajan, 1990). The factors affecting the efficiency of sample contract and non-contract farmers can be classified into two groups—those associated with technical knowledge and those related to socio-economic variables. The regressions that identify the contributions of selected variables in explaining variations in production efficiency are reported in Table 8.

Table 8 reveals that the results indicated that the number of times of agro-chemicals use has contributed significantly to the efficiency in growing a contract crop. For non-contract crop that is grown by contract and non-contract farmers, the determinant of achieving technical efficiency was education. The estimated coefficient of education indicated that farmers with education could achieve a higher level of efficiency in growing of a contract crop, while it was not the case of contract crop. This result can be explained in the line of internalisation of knowledge by the processing firm (Glover, 1984; Chang *et al.*, 2006). The insignificance of education in case of non-contract crop is understandable because the production strategy is guided by the processor and there is little space for a

[11] A one-stage method is more consistent for measuring the determinants of technical efficiency. However, in this study a two-stage method has been used because of non-availability of a statistical package. First, I have estimated farm-level technical efficiency, and then taken this as a dependent variable.

farmer's knowledge. We did not find the impact of age of a farmer on efficiency level.

Conclusions and Way Forward

The literature and empirical studies of contract farming has discovered that crops grown under contract mode of production have better productivity and farmers are efficient compared to non-contract ones. Further, it also emphasized the role of input supply including better technology and assurance in procurement of output in explaining the existence and success of contract production. This is undoubtedly the case in the instance of our study. The study, in line with the concept of contract farming, has found that farmers growing contract crop are more efficient than non-contract growers. In addition, contract farmers could achieve higher productivity in growing contract crops as compared to non-contract crop. However, it is significant to find that non-contract farmers could achieve a higher productivity in growing non-contract crop compared to contract farmer.

The study has revealed that application of inputs and produce yield per acre varied across crops and also across farmers. The factors like labour, agro-chemicals and region have shown a significant contribution to total output of the contract crop, while labour, agro-chemicals, power and region have shown significant impact on total output of non-contract crop that is being grown by the non-contract farmers. On the other hand, factors like land, labour, power and region have substantial impact on the output of non-contract crop grown by a non-contract farmer. The results have indicated that while agro-chemicals play an important role in achieving good output of contract and non-contract crops grown by the contract farmers, it is not so when it comes to the non-contract farmers. The implication of the result is that growing contract crops induces farmers to use more agro-chemical for achieving higher outputs, which puts the question on sustainability of soil quality. Since contracts in contract farming do not include sustainability of soil quality and sustainable use of groundwater, the government could take initiatives such as promoting drip irrigation and organic farming (may be through subsidies).

The results of productivity differences between contract and non-contract farmers in growing non-contract crop have indicated that non-contract farmers are more productive than contract farmers. On other hand, the productivity difference between contract and non-contract crops that are grown by contract farmers have indicated that farmers could achieve higher productivity in growing contract crop as compared to non-contract crop. The estimated result of technical efficiency have revealed that contract farmers are more efficient in growing contract crops (mean efficiency level: 89%) than the non-contract crops (mean efficiency level: 87%). However, contract farmers are less efficient than non-contract farmers when it comes to non-contract crop. It was due to complete dependence of farmers on companies leading to an erosion of their traditional knowledge. To protect the traditional knowledge, farmers should have freedom to exercise their traditional knowledge and modern knowledge should be better merged with traditional one.

The results have pointed out many avenues for future research; these include the autonomy of farmers in contract farming, technology spill-over effect, and impact of modern technology in contract farming on farmer's traditional knowledge and local environment.

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